A Situational Awareness Tool

For

Unmanned Aerial Vehicles (UAVs)

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Introduction

With the emergence of Unmanned Aerial Vehicles (UAVs) and the video payloads now available onboard, real-time surveillance of dynamic situations is now possible. Air Force commanders are often required to make critical decisions during these dynamic situations based on limited information. In order to increase the situational awareness of commanders, we have developed a prototype UAV Situational Awareness Tool. This tool will connect the commander in a command center to an operational UAV in the field.

The prototype tool we have developed is based on a Geographic Information System (GIS) displaying a map of the situation area along with a video feed from the UAV. By displaying the location of the UAV on the GIS map along with the video feed from the UAV, commanders will have a bird's eye view of dynamic situations. Using this tool in a command center during exercises will increase the situational awareness of Air Force Commanders.

In his concept paper [1], Harper describes a dynamic situation that includes two separate emergency events occurring on the Air Force Academy. As the base commander responses to these events, it is imperative to have accurate, real-time data about the situations. By combining existing technologies in GIS systems, UAV video feeds, and networking technology, our prototype tool provides the commander a real-time video feed from a single UAV. This video feed provides the commander real-time visual information that will greatly increase his/her situational awareness. This prototype tool addresses Harper's concept paper [1] and provides an initial capability for response to these types of situations.

Research Objectives

Display a UAV icon in a GIS Application

The first objective is to build a GIS application that interfaces with the UAV's onboard autopilot. The GIS application needs the current position of the UAV in order to show the correct location on the map. This information is gleaned from the telemetry information being received from the UAV.

Display the Video Feed from a UAV

The next objective is to capture the video stream being sent from the UAV and embed it in the GIS application.

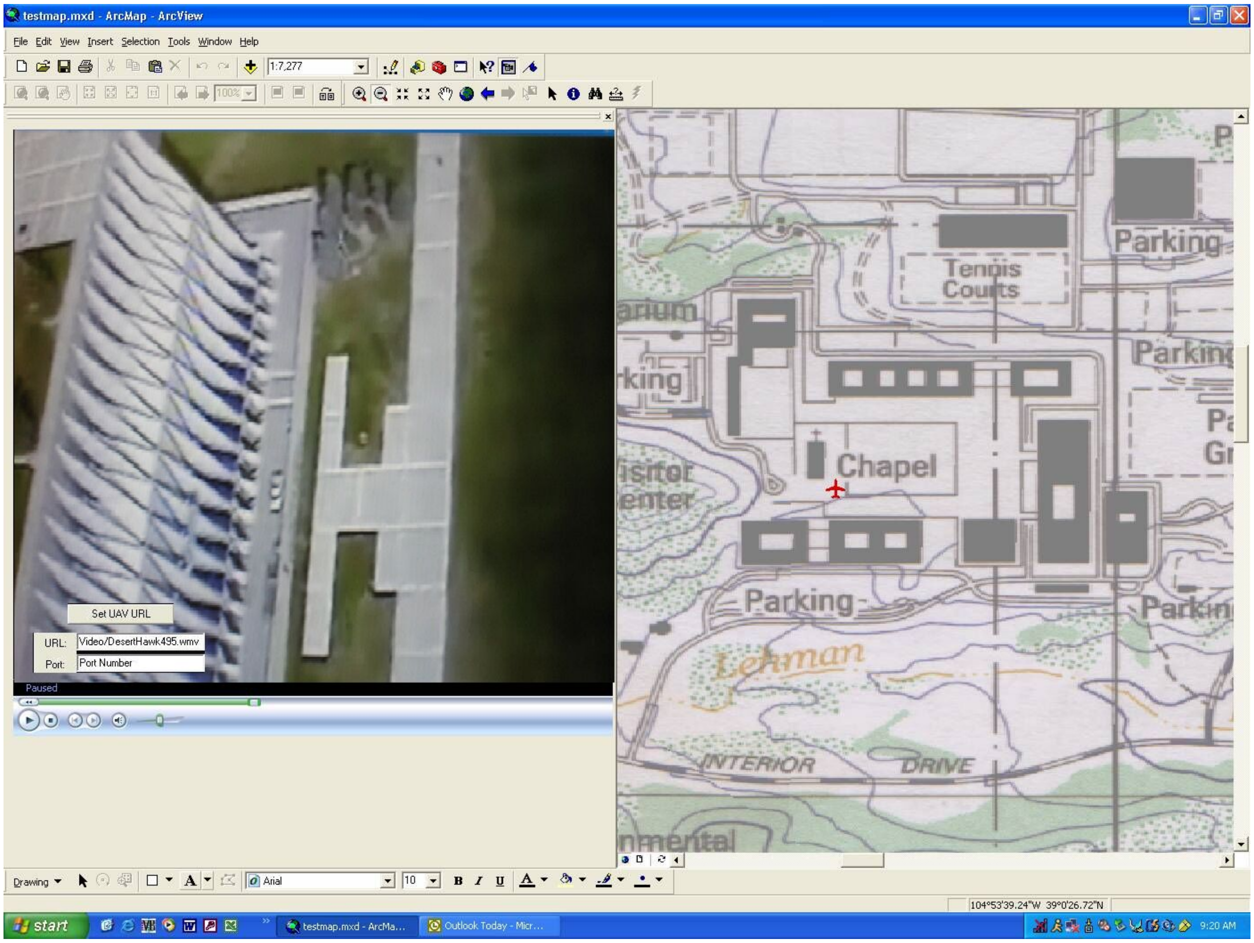
Provide the UAVSAT Tool to Commanders in a Command Center

The final objective is to connect the commander in the command center to the operational UAV flying in the field. We developed a client/server architecture to support this objective.

The UAV Situational Awareness Tool

Figure 1 shows a screen capture from the prototype UAV Situational Awareness Tool (UAVSAT). The tool is based on existing GIS technology [2] which allows the user to overlay any number of information layers onto an existing map object. GIS systems are currently being used by security forces to display maps, secure cordons, response vehicles, etc, during emergency situations. Figure 1 shows the video stream from the UAV on the left of the screen

and the location of the UAV on the right side of the screen. The video window is based on Microsoft's Windows Media player ™. This window is a dockable window that can be detached from the main UAVSAT window. This allows the user to display the video on one screen and the GIS map image on another if multiple screens are available.



URL: Video/DesertHawk495.wmv

Port: Port Number

104°53'39.24"W 39°0'26.72"N

Figure 1 Screen Capture from UAVSAT

The UAVSAT tool includes a UAV icon in the GIS display, which moves around the map and shows the current location of the UAV during flight. The latitude and longitude of the UAV, taken from the UAV's telemetry data, are used to geolocate the UAV on the map display. In Figure 1, this icon is shown currently southeast of the Chapel.

Figure 2 shows the overall system architecture we used to provide both the video and the telemetry data to the UAVSAT tool.

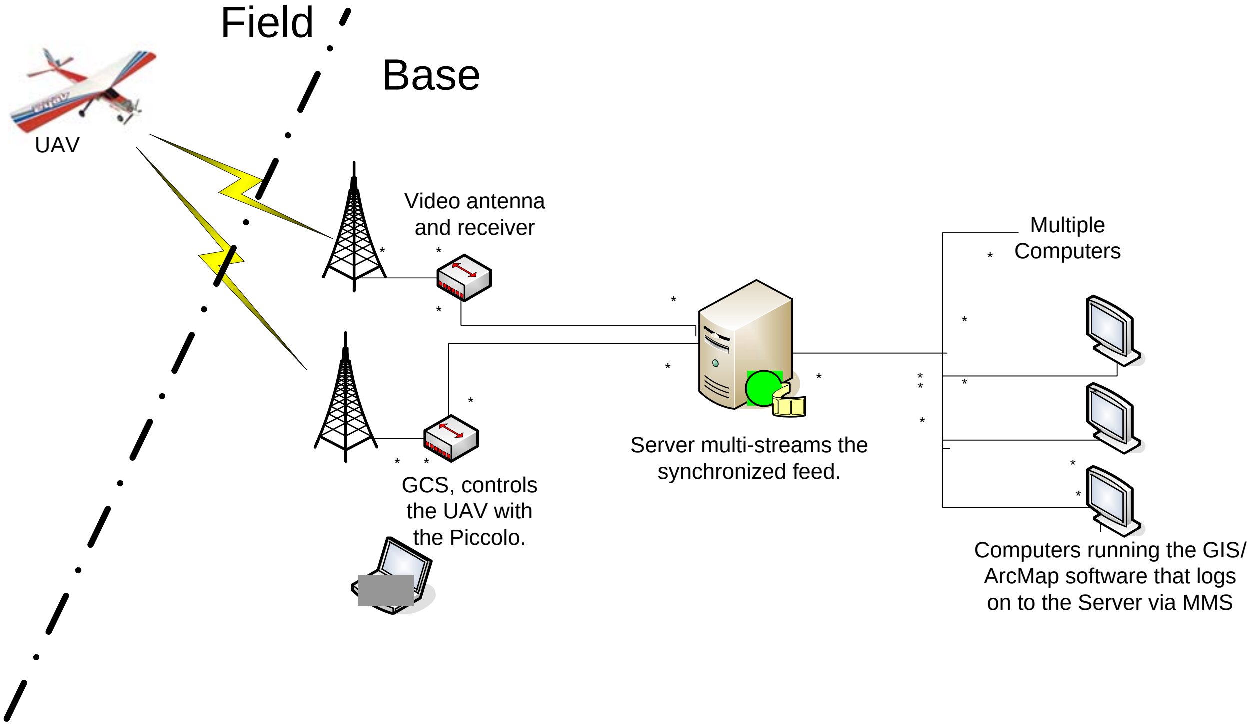


Figure 2 Overall System Architecture

The telemetry from the UAV is sent from the onboard autopilot to the Ground Control Station (GCS) via a 900 MHz channel. This telemetry includes latitude, longitude, altitude, pitch, roll, yaw, etc., as described in the Piccolo communications documentation [3]. The UAV telemetry is sent to the server and converted into a form that is sent to all the clients via a program developed for this project. On a separate stream, the video images are sent from the onboard camera to the receiver on the ground via a 2.4 GHz channel. These video images are sent to the server and converted to a format that is capable of being streamed to the clients. This process is done by the Microsoft Windows Media Server. This process can take from six to nine seconds to perform, which results in a delay of six to nine seconds from the time the video was shot onboard the UAV to the time it can be displayed in the command center. The clients connect to the server via an Internet Protocol (IP) connection and receive telemetry and video information over IP.

Integrating video into a GIS application is not a new technology. However, the authors have not found a system that integrates real-time video with telemetry data into a GIS application using an Internet connection. The Red Hen Systems Corporation [4] provides a video capture and playback facility for ESRI products such as ArcMap and ArcGIS, but this is not a real-time video feed. Their GeoVideo application provides a means of capturing geo-referenced DVD video and the ability to replay the video in ArcGIS applications. Geo-referenced still images can be captured during playback of the DVD video [4]. The GeoVideo application was used by students from the University of Nebraska to build *gNet*, an interactive map of the Lewis and Clark explorations. [5] The *gNet* systems is not a real-time video system. Similarly, the Iwane Video GIS system [6] allows the user to view digitized videos of selected locations, but it is not a real-time video system.

UAVs at the Air Force Academy

The UAVs used for this research are based on the Piccolo autopilot system as shown in Figure 3. This autopilot system includes a Software Developer's Kit (SDK) that can be used to develop specialized UAV applications based on the C++ programming language.

Figure 3 Piccolo Autopilot

The Piccolo autopilot is used in such UAVs as the Silver Fox, Pointer, and Aerosonde. Due to operational and financial limitations, we have based our research on a UAV built from the Alpha 60™ remote controlled model airplane [7]. Figure 4 shows a UAV based on the Alpha 60, which has been configured to fly with a Piccolo autopilot. The same Ground Control Station (GCS) that is used for the Silver Fox UAV is used to control the Alpha 60-based UAV. Due to altitude limitations at the Academy, we also add a larger engine to the Alpha 60.

Figure 4 UAV based on Alpha 60™

A system for video capture was developed under a previous grant to Lt Col Sward [8]. Flight tests with this inexpensive camera payload have shown that a camera with better resolution and range was needed. It is especially crucial to have a higher resolution camera for video capture missions. It is also crucial to have reasonable range capability for the camera system. During the earlier video capture missions, the signal between the camera transmitter and receiver was

often lost. This resulted in distracting flashes of static and black screens in the video capture image. These limitations will be magnified during real-time crisis situations when the commander needs good quality video signals.

Figure 5 Color CCD Camera

To solve the resolution problem with our existing video capture system, we purchased the camera shown in Figure 5. This camera is a color Charged Couple Device (CCD) camera with 450 TV lines of resolution. This provided better resolution for video capture missions.

Figure 6-Video Transmission System

To solve the range problem with our existing video capture system, we purchased the video transmission system shown in Figure 6. This system provided a greater range for our video capture system.

Additional Results

The 15 cadets enrolled in the computer science course, CS-453, Software Engineering, were divided into three groups, each composed of a team leader, a design engineer, and two programmers. The teams consisted of a Field of View Team, a Streaming Media Delay Team, and an Automatic Orbit Establishment Team. An integration officer was responsible for integrating the work of the teams. Overall, a program manager and an assistant managed the work.

At specified intervals during the course, the groups were required to produce reports of progress on assigned work, including achievements and challenges. In fulfilling the multi-faceted requirements, the cadets participated in developing software as a part of a large development team, combining project management, programming, integration, and system deployment skills.

Work Remaining

Because of the processing time required for Microsoft Windows Media Server to prepare the video for streaming, there is a time delay introduced between when the video was shot onboard the UAV and when it is presented to the client applications in the command center. This delay can be from six to nine seconds in length and is not a constant length. Because of this delay, there is a synchronization problem between when the video was shot and where the UAV is shown on the GIS map display. Since there is little delay in the transmission of the UAV's location, the difference between where the UAV is shown on the map and the location that the video is currently showing can be sizable. Future research should work on minimizing this delay and this synchronization problem between the location of the UAV on the map and the video stream.

Currently, the distance between the video receiver and the server computer is not great. In order to deploy this system to the field, there must be some way to increase the distance between where the video signal is being captured by the receiver and where the server is that is streaming the video signal to the clients. Future research should work on extending the distant between the receiver and the server.

Project Summary

Overall, the project was a success in that we developed a prototype system that demonstrates it is possible to connect the commander in a command center with the video from and the location of an airborne UAV. The UAVSAT tool incorporates UAVs as another layer of information available to the commander in his/her GIS toolkit. This combination of the video and the location of the UAV is a powerful asset for the commander during a crisis situation.

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